A Low-Cost Multi-Terrain Autonomous Vehicle for Hostile Environments*

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ABSTRACT

This paper describes an innovative and unique autonomous vehicle system being developed at the Lawrence Livermore National Laboratory (LLNL) for versatile use in hostile environments. Conventional vehicles used in decommissioning and decontamination, police activity and unmanned military operations typically are designed with four-wheels or tracks in contact with the environment. Although four-wheel and track vehicles work well, they are extremely limited in the types of terrain that can be negotiated. The Spiral Track Autonomous Robot (STAR) system is an automated mechanism which uses left and right-hand Archimedes screws, in contact with the terrain, to propel itself along the local environment. By rotating the screws in one of the different rotation combinations, it is possible to move the vehicle four translational directions and two rotational directions. Unlike conventional four-wheel vehicles, this design has resulted in a mobile vehicle with a low center-of-gravity (cg) capable of traversing multiple terrains at significantly steeper inclines. The hollow cylindrical screws with outer pitch blades, combined with a lightweight construction, help to give the vehicle enough buoyancy and water displacement for negotiating saturated terrain and streams. Multiple modes of operation include wireless remote control and autonomous computer control. Autonomous operation of the vehicle is accomplished by the on board computer system, control software and GPS receiver for positioning. The mechanical frame and sturdy construction allow for mounting of various sensors as needed by the task to be accomplished.

Mounted with the Micropower Impulse Radar (MIR) land mine detection technology developed here at LLNL, the STAR becomes a low cost (as low as $5,000) sensor deployment vehicle. When further equipped with CCD cameras and infrared sensors for multi-sensor operation, the STAR becomes a much more versatile and effective land mine detection system and unmanned reconnaissance vehicle. Placement of radiation and gas sensors transform the STAR into a cost-effective solution for unmanned radiation detection in remote areas not easily accessible by conventional four-wheel vehicles. Equipped with heat sensing technology and audio microphones, the STAR can be utilized as a search and rescue vehicle in fragile and hostile environments.

Such versatility in application is achieved by a flexible electronic and mechanical design. The onboard computer system contains multiple bus slots for interchangeability of CPU peripherals as needed, the mounting of the Archimedes screws has been done to make it simple to change to screws with varying pitches and traction if desired, all video and data are transmitted and received via wireless transceivers, and power is placed onboard for complete tetherless operation. Tests on phase 1 of the system have proven operation in multiple terrains including stair climbing, mud, water, sand, hard, rocky and soft soils. Current and future work includes a re-designed mechanical frame for multiple sensor fusion and electronics integration.

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